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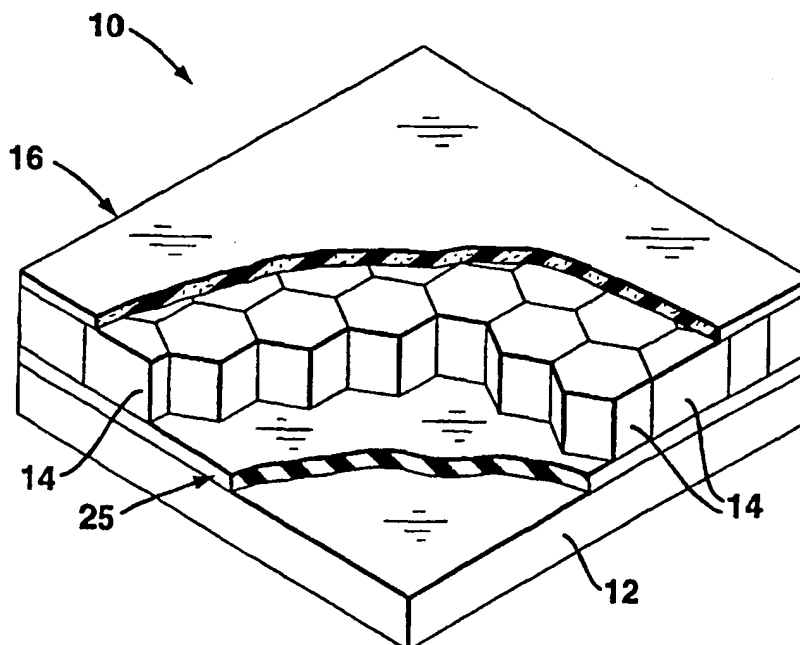
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/US98/03128 (22) International Filing Date: 18 February 1998 (18.02.98) (30) Priority Data: 08/803,040 19 February 1997 (19.02.97) US (71) Applicant: UNITED DEFENSE, L.P. [US/US]; Office of General Counsel, Suite 700, 1525 Wilson Boulevard, Arlington, VA 22209 (US). (71)(72) Applicant and Inventor: MOORE, Franklin, C. [US/US]; 215 South Thistle Lane, Maitland, FL 32751 (US). (72) Inventors: SCHADE, David, Arthur; 8 Cranfield Avenue, San Carlos, CA 94070 (US). MCARTHUR, Michael, Brian; 14629 Branham Lane, San Jose, CA 95124 (US). PIKE, Torrey, Lane; 155 Lawnview Circle, Danville, CA 94526 (US). THOMAS, George, Edgar, Jr.; 161 S. California Avenue #K-204, Palo Alto, CA 94306 (US). MIDDIONE, Mark, Albert; 16 Cooper's Hawk Court, Scotts Valley, CA 95066 (US). (74) Agent: CALDWELL, John, W.; Woodcock Washburn Kurtz Mackiewicz & Norris LLP, 46th floor, One Liberty Place, Philadelphia, PA 19103 (US).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>With amended claims and statement.</i>

(54) Title: COMPOSITE ARMOR FOR A VEHICLE AND METHOD FOR MANUFACTURING SUCH AN ARMOUR

**(57) Abstract**

The invention provides an improved composite armor system that may be used for an upper hull for a composite armor vehicle. The invention provides a complete composite armor system. A composite armor support layer is formed by the hull of the vehicle or protective system. Armor tiles are attached to the composite armor support layer to improve the armor protection. A signature layer is then applied.

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COMPOSITE ARMOR FOR A VEHICLE AND METHOD FOR MANUFACTURING SUCH AN ARMOUR

5 BACKGROUND OF THE INVENTION

The present invention relates generally to composite armor used on an upper hull of a vehicle.

In the prior art, composite armor vehicles did not provide sufficient protection.

10

SUMMARY OF THE INVENTION

It is an object of the invention to provide a composite armor which provides sufficient protection to the upper hull of a composite armor vehicle.

15

It is another object of the invention to provide ceramic tile armor on a composite vehicle that can sustain multiple hits.

The invention provides an improved method and apparatus for creating a composite armor package. The invention uses a toughened epoxy adhesive and a rubber interlayer to improve the bonding of ceramic tile to armor and provides a means of providing a desired radar signature.

20

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cut away perspective view of a preferred embodiment of the invention.

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Figure 2 illustrates a detailed perspective view of the attachment layer illustrated in Figure 1.

Figure 3 is a schematic view of the signature layer illustrated in Figure 1.

30

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A armor system 10, as shown in Figure 1, may be used on a composite armor military vehicle or for other types of composite armor

- 2 -

protection. A armor system 10, comprises a composite support layer 12, an interlayer 25, a layer of ceramic tiles 14, and a signature layer 16.

In the preferred embodiment, the composite support layer 12 is made of fiberglass, preferably S-2 glass. The S-2 glass is uni-
5 directional fiberglass tape (unitape) layer between 0.75 inches and 1 inch thick. In other embodiments, the fiberglass may use a bidirectional woven fiberglass piece.

Figure 2 illustrates a detailed perspective view of the interlayer 25 illustrated in Figure 1. The interlayer 25, comprises a first
10 layer of epoxy 27 between a first side of the composite support layer 12 and a first side of a layer of EPDM rubber 28, a first scrim cloth 29, which comprises an open weave of fiberglass material embedded in the first layer of epoxy 27, a second layer of epoxy 30 between a second side of the layer of EPDM rubber 28 and a first side of the layer of ceramic tiles 14,
15 and a second scrim cloth 31, which comprises an open weave of fiberglass material embedded in the second layer of epoxy 30. The ceramic tiles 14 are of an armor ceramic. In the preferred embodiment the armor ceramic of the layer of ceramic tiles 14 are Cercom hot pressed silicon carbide Type N tiles made by Cercom Incorporated at 1960 Watson Way, Vista,
20 California 92063. The signature layer 16 is place over the layer of ceramic tiles 14 and the edges of the armor. The signature layer 16 is described in more detail below.

In the manufacture of the preferred embodiment the composite support layer 12 is first prepared by removing all oil and grease
25 from the surface of the composite support layer, and then by sand blasting or grinding the surface to be bonded. The first and second sides of the layer of EPDM rubber 28 are sanded with 80-grit paper, so that the surface gloss is removed. The ceramic tiles of the layer of ceramic tiles 14 are cleaned. The layer of ceramic tiles 14, the layer of EPDM rubber 28, and
30 the composite support layer 12 are primed. The primer promotes surface bonding with the adhesive. SC-11 epoxy, which is a toughened epoxy made by Applied Polymeric Incorporated (API) at 850 Teal Drive, Benicia, California 94510, is mixed and 5% by weight of fumed silica is mixed into the epoxy to thicken the epoxy and make it easier to work with. The
35 epoxy is spread over the first side of the composite support layer 12. The first scrim cloth 29 is placed on the epoxy spread over the first side of the

- 3 -

composite support layer 12. Epoxy is spread over the first scrim cloth 29, thus forming the first layer of epoxy 27 with the first scrim cloth 29 embedded therein. The first scrim cloth 29 serves as a wick and spacer to uniformly distribute the epoxy between the layer of EPDM rubber 28 and the ceramic tiles 14. The layer of EPDM rubber 28 is placed on the first layer of epoxy 27. Epoxy is spread over the second side of the layer of EPDM rubber 28. The second scrim cloth 31 is placed over the epoxy spread over the second side of the layer of EPDM rubber 28. Epoxy is spread over the second scrim cloth 31, thus forming the second layer of epoxy 30 with the second scrim cloth 31 embedded therein. The layer of ceramic tiles 14 is placed on the second layer of epoxy 30. Epoxy is placed over the tiles to fill in gaps, and allowed to cure over night. The dimension of the gap between the tiles is between 0.010 inches and 0.10 inches. When protection between multiple hits is desired a gap of 0.015 inches is preferred. When protection from small threats is desired a gap of 0.080 is preferred.

Figure 3 is a schematic view of the signature layer 16, which is a radar attenuating layer. A layer of epoxy is placed on the layer of ceramic tiles 14. A ground plane scrim 21, formed by a tightly woven graphite cloth, is placed on the layer of epoxy on the layer of ceramic tiles 14. A layer of epoxy is placed on the ground plane scrim 21. Plastic is placed over the epoxy on the ground plane scrim 21 and a vacuum is used to draw the epoxy into the ground plane scrim 21. The plastic is then removed from the epoxy. A first plurality of layers of fiberglass 22 impregnated with epoxy and a radar attenuating material manufactured by Lockheed/Martin are placed over the tightly ground plane scrim 21. The type of radar attenuating material and type and number of layers of fiberglass are dependent on the desired radar signature. Other types of radar attenuating layers may be used for the signature layer. Such radar attenuating layers are known in the prior art. In the preferred embodiment the first plurality of layers of fiberglass 22 are six layers of 977 fiberglass, which has a tight weave and thin fibers. A second plurality of layers of fiberglass 23 impregnated with epoxy, but not treated with radar attenuating material are placed over the first plurality of layers of fiberglass 22. In the preferred embodiment the second plurality of layers of fiberglass 23 are three layers of 977 fiberglass, which has a tight weave

- 4 -

and thin fibers. The signature layer 16 comprises the ground plane scrim 21, the first plurality of layers of fiberglass 22 and the second plurality of layers of fiberglass 23.

5 The composite support layer 12 forms part of a composite military vehicle or a building, where protection from munitions is desirable. When the armor system 10 in the preferred embodiment was hit with a projectile, the inventive armor minimized ceramic tile displacement, by limiting the tiles removed or damaged by the projectile to a small area.

10 In other embodiments, other types of adhesives may used instead of SC-11 epoxy. Other elastomer materials may be used in place of EPDM rubber replacing the layer of EPDM rubber with an elastomer layer. Other embodiments may leave out the scrim cloth or use a scrim cloth of a different material. Other types of interlayers may be used to bind the
15 ceramic tiles 14 to the composite support layer 12, such as replacing the EPDM rubber with fiberglass. The ceramic tiles 14 may be made of other armor ceramics. Armor ceramics are made of a high density, high strength crystalline material, such as alumina. In some armor ceramics, the crystalline material is bonded with an amorphous substance such as
20 glass.

The wrapping of the signature layer around the edges of the composite support structure, signifies that edges of the composite support structure are wrapped to provide the desired radar signature.

25 The use of a composite support layer instead of a metallic support layer, provides inherent spall protection and a light weight inexpensive armor. Therefore the invention is a light weight inexpensive armor that is able to withstand many conventional threats and has radar attenuation properties and inherent spall protection in a single package.

30 While preferred embodiment of the present invention has been shown and described herein, it will be appreciated that various changes and modifications may be made therein without departing from the spirit of the invention as defined by the scope of the appended claims.

- 5 -

What is claimed is:

1. An composite armor system, comprising:
 - a composite support layer;
 - a plurality of tiles forming a layer of tiles with a first side and a second side;
 - an interlayer binding the layer of tiles to the composite support layer; and
 - a attenuating layer with a first side and a second side, wherein the first side of the signature layer is bonded to the second side of the layer of tiles.
2. The composite armor system, as claimed in claim 1, wherein the interlayer, comprises:
 - an elastomer layer with a first side and a second side with the first side of the elastomer layer adjacent to the first side of the composite support layer;
 - a first adhesive layer binding the first side of the composite support layer to the first side of the elastomer layer;
 - a second adhesive layer binding the second side of the elastomer layer with the first side of the layer of tiles; and
3. The composite armor system, as claimed in claim 2, wherein the signature layer, comprises:
 - a ground plane scrim with a first side and a second side, wherein the first side of the ground plane is bonded to the second side of the layer of tiles; and
 - a first plurality of layers of fiberglass impregnated with an epoxy with a first side and a second side, wherein the first side of the first plurality of layers of fiberglass are bonded to the second side of the ground plane scrim.
4. The composite armor system, as claimed in claim 3, wherein the signature layer, further comprises, a second plurality of layers of fiberglass with a first side and a second side, wherein the first side of the second plurality of layers of fiberglass is bonded to the second side of the first plurality of layers of fiberglass.

5. The composite armor system, as claimed in claim 4, wherein the first plurality of layers of fiberglass is impregnated with a radar attenuating material, and wherein the second plurality of layers of fiberglass is not impregnated with the radar attenuating material.

6. The composite armor system, as claimed in claim 5, wherein the tiles of the layer of tiles are made of an armor ceramic.

7. The composite armor system, as claimed in claim 6, wherein the ground plane scrim is a woven graphite cloth.

8. The armor system, as claimed in claim 7, further comprising:

- a first scrim cloth embedded in the first adhesive layer; and
- a second scrim cloth embedded in the second adhesive layer.

9. The armor system, as claimed in claim 8, wherein the scrim cloth is a net of fiberglass material.

10. The armor system, as claimed in claim 9, wherein the elastomer layer is EPDM rubber.

11. The armor system, as claimed in claim 10, wherein the first adhesive layer and the second adhesive layer are epoxy layers.

12. The composite armor system, as claimed in claim 3, wherein the tiles of the layer of tiles are made of an armor ceramic.

13. The composite armor system, as claimed in claim 12, wherein the ground plane scrim is a woven graphite cloth.

14. The armor system, as claimed in claim 13, further comprising:
a first scrim cloth embedded in the first adhesive layer; and
a second scrim cloth embedded in the second adhesive layer.

- 7 -

15. The armor system, as claimed in claim 14, wherein the scrim cloth is a net of fiberglass material.

16. The armor system, as claimed in claim 15, wherein the elastomer layer is EPDM rubber.

17. The composite armor system, as claimed in claim 1, wherein the tiles of the layer of tiles are made of an armor ceramic.

18. A method of manufacturing an armor system, comprising the steps of:

bonding a first side of an elastomer layer to a first side of a composite support layer;

bonding a first side of a layer of ceramic tiles to a second side of the elastomer layer; and

bonding a signature layer to a second side of the layer of ceramic tiles.

19. The method, as claimed in claim 18, wherein the step of bonding the signature layer, comprises the steps of:

bonding a first side of a ground plane scrim to the second side of the layer of tiles; and

bonding a first side of a first plurality of layers of fiberglass to a second side of the ground plane scrim.

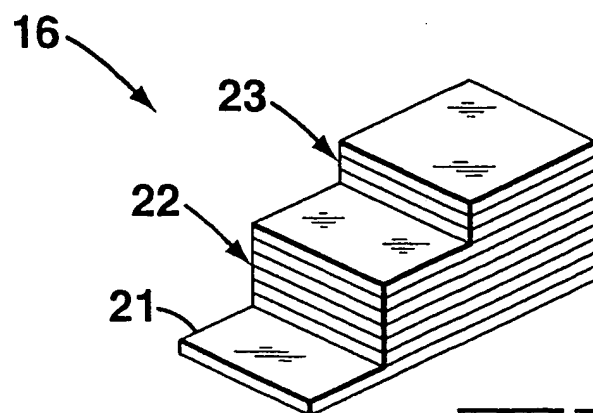
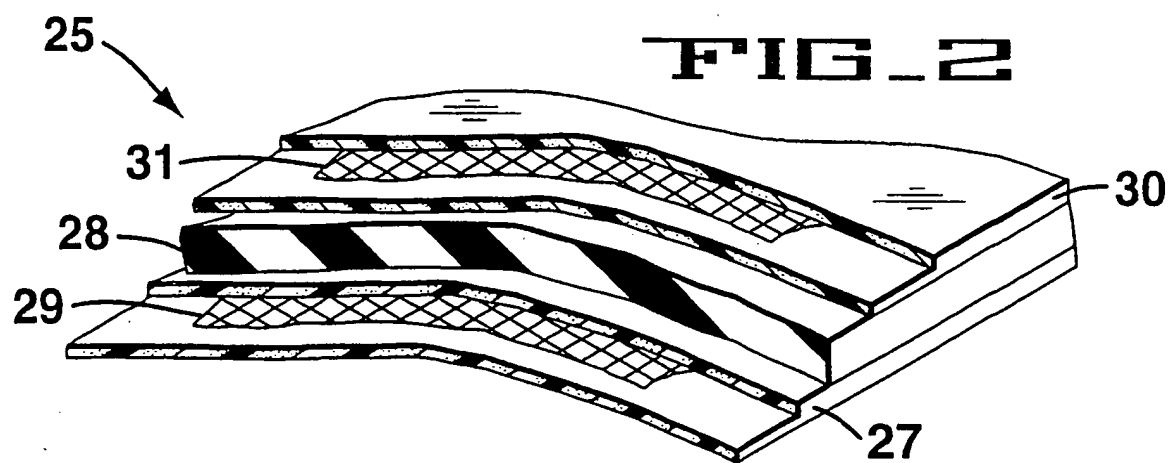
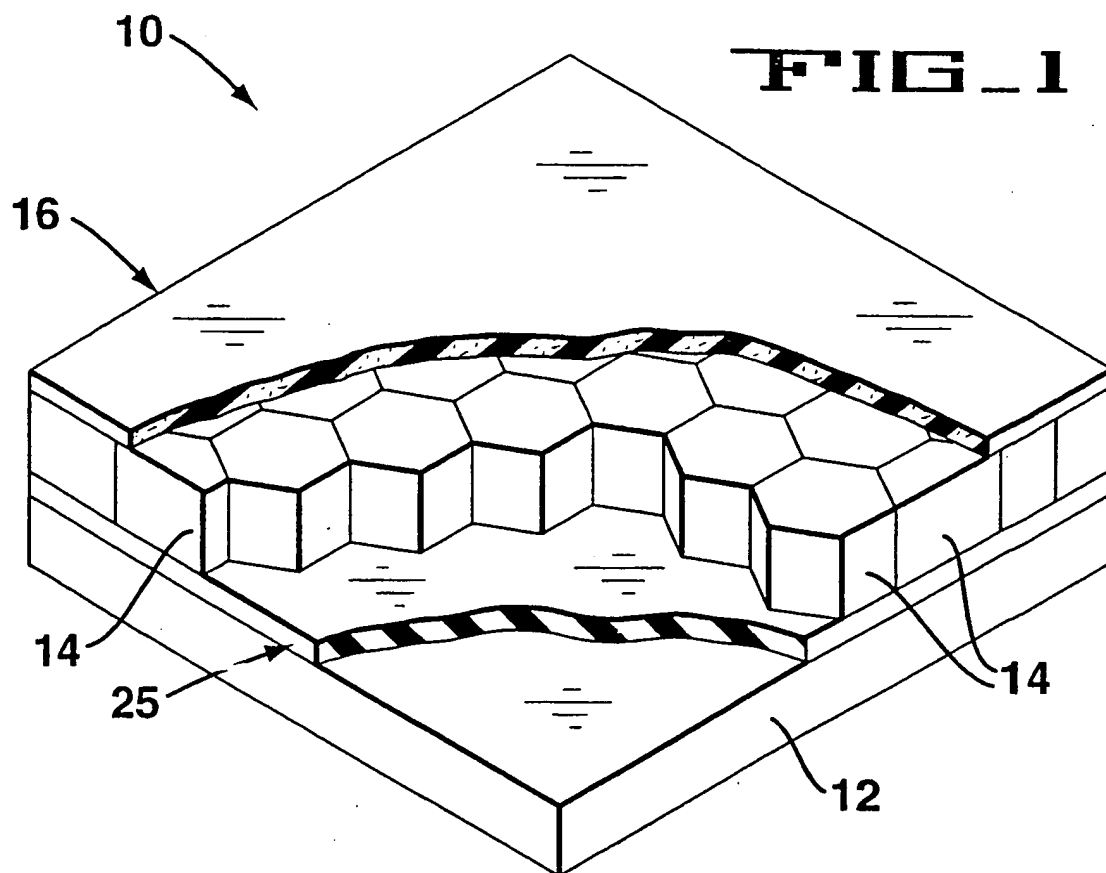
20. The method, as claimed in claim 19, wherein the step of bonding the signature layer, further comprises the step of, bonding a first side of a second plurality of layers of fiberglass to a second side of the first plurality of layers of fiberglass, wherein the first plurality of layers of fiberglass is impregnated with a radar attenuating material and the second plurality of layers of fiberglass is not impregnated with the radar attenuating material.

AMENDED CLAIMS

[received by International Bureau on 15 July 1998 (15.07.98);
original claims 1 and 2 amended; remaining claims unchanged (1page)]

1. An composite armor system, comprising:
 - a composite support layer;
 - a plurality of tiles forming a layer of tiles with a first side and a second side;
 - an interlayer binding the layer of tiles to the composite support layer; and
 - a signature layer with a first side and a second side, wherein the first side of the signature layer is bonded to the second side of the layer of tiles.
2. The composite armor system, as claimed in claim 1, wherein the interlayer, comprises:
 - an elastomer layer with a first side and a second side with the first side of the elastomer layer adjacent to a first side of the composite support layer;
 - a first adhesive layer binding the first side of the composite support layer to the first side of the elastomer layer;
 - a second adhesive layer binding the second side of the elastomer layer with the first side of the layer of tiles; and
3. The composite armor system, as claimed in claim 2, wherein the signature layer, comprises:
 - a ground plane scrim with a first side and a second side, wherein the first side of the ground plane is bonded to the second side of the layer of tiles; and
 - a first plurality of layers of fiberglass impregnated with an epoxy with a first side and a second side, wherein the first side of the first plurality of layers of fiberglass are bonded to the second side of the ground plane scrim.
4. The composite armor system, as claimed in claim 3, wherein the signature layer, further comprises, a second plurality of layers of fiberglass with a first side and a second side, wherein the first side of the second plurality of layers of fiberglass is bonded to the second side of the first plurality of layers of fiberglass.

1/1



INTERNATIONAL SEARCH REPORT

International Application No.

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A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 F41H5/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 F41H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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